JEE Main 2020 Paper

Date: 9th January 2020
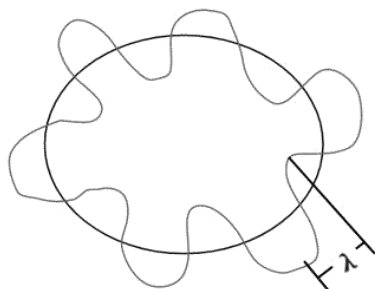
Time: 09.30 AM – 12:30 PM

Subject: Chemistry

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1. Determine the wavelength of electron in the 4th Bohr's orbit:
    a. $4\pi a_0$
    b. $2\pi a_0$
    c. $8\pi a_0$
    d. $6\pi a_0$

    Answer: c

    Solution: n=4
    Z=1
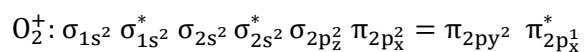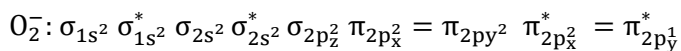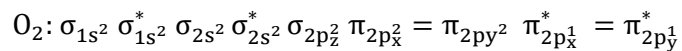 Λ=?

    Circumference $(2\pi r) = n\lambda$
    $\frac{2\pi a_0 n^2}{z} = n\lambda$
    On solving, we get $8\pi a_o$

2. Which of the following species have one unpaired electron each?
    a. O_2, O_2^-
    b. O_2, O_2^+
    c. O_2^+, O_2^-
    d. O_2, O_2^{2-}

    Answer: c

    Solution:

    $O_2: \sigma_{1s^2} \, \sigma^*_{1s^2} \, \sigma_{2s^2} \, \sigma^*_{2s^2} \, \sigma_{2p_z^2} \, \pi_{2p_x^2} = \pi_{2py^2} \; \pi^*_{2p_x^1} = \pi^*_{2p_y^1}$

    $O_2^-: \sigma_{1s^2} \, \sigma^*_{1s^2} \, \sigma_{2s^2} \, \sigma^*_{2s^2} \, \sigma_{2p_z^2} \, \pi_{2p_x^2} = \pi_{2py^2} \; \pi^*_{2p_x^2} = \pi^*_{2p_y^1}$

    $O_2^+: \sigma_{1s^2} \, \sigma^*_{1s^2} \, \sigma_{2s^2} \, \sigma^*_{2s^2} \, \sigma_{2p_z^2} \, \pi_{2p_x^2} = \pi_{2py^2} \; \pi^*_{2p_x^1}$
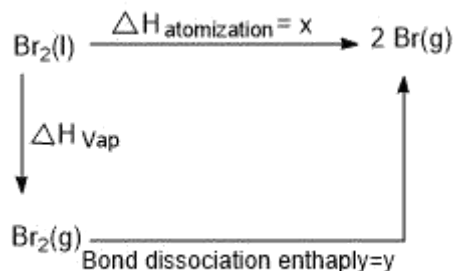
3.   For $Br_2(l)$, the enthalpy of atomisation = x kJ/mol and the bond dissociation enthalpy of bromine = y kJ/mol. Then,
   a.   x > y
   b.   x < y
   c.   x = y
   d.   Relation does not exist.

   Answer: a

   Solution:

   $\Delta H_{atomisation} = \Delta H_{vap} + y$

   $x - y = \Delta H_{vap}$

4.   Which of the following oxides are acidic, basic and amphoteric, respectively?
   a. MgO, P_4O_{10}, Al_2O_3
   b. N_2O_3, Li_2O, Al_2O_3
   c. SO_3, Al_2O_3, Na_2O
   d. P_4O_{10}, Al_2O_3, MgO

   Answer: b

   Solution:

   Non-metallic oxides are acidic in nature, metallic oxides are basic in nature and Al_2O_3 is amphoteric in nature

5. The complex $Cr(H_2O)_6Cl_n$, shows geometrical isomerism and also reacts with $AgNO_3$ solution. Given: The spin only magnetic moment = 3.8 B. M. What is the IUPAC name of the complex?
   a. Hexaaquachromium(III) chloride
   b. Tetraaquadichloridochromium(III) chloride dihydrate
   c. Hexaaquachromium(IV) chloride
   d. Tetraaquadichloridochromium(IV) chloride dehydrate

   Answer: b

   Solution:

   Spin only magnetic moment = 3.8 B. M. This implies, $\mu = \sqrt{(n(n+2))}$ B.M.

   $(\sqrt{16} = 4$ implies that $\sqrt{15}$ should be less than four.

   This means, n=3 as $\sqrt{15} = \sqrt{(3(3+2))}$

   Cr (24) = $[Ar]4s^1\, 3d^5$

   (g.s)

   For 3 unpaired electrons, the oxidation state of Cr should be +3

   Cr^{3+} can be attained if the complex has a structure that looks like: $[Cr(H_2O)_4Cl_2]Cl.\, 2H_2O$

   $[Cr(H_2O)_4Cl_2]Cl.\, 2H_2O$ has the IUPAC name : Tetraaquadichloridochromium(III) chloride dihydrate

6. The electronic configuration of bivalent Europium and trivalent Cerium, respectively is: (Atomic Number : Xe = 54, Ce = 58, Eu = 63)
   a. $[Xe]4f^7, [Xe]4f^1$
   b. $[Xe]4f^7 6s^2, [Xe]4f^1$
   c. $[Xe]4f^7 6s^2, [Xe]4f^1 5d^1 6s^2$
   d. $[Xe]4f^7, [Xe]4f^1\, 5d^1 6s^2$

   Answer: a

   Solution:

   Ce (58): $[Xe]\, 6s^2 4f^2$

   (g.s)

   Ce^{3+}: $[Xe]4f^1$

   Eu(63) : $[Xe]6s^2 4f^7$

   (g.s)

   Eu^{2+} : $[Xe]4f^7$

7. K_{sp} of $PbCl_2 = 1.6 \times 10^{-5}$. On mixing 300 mL, 0.134 M $Pb(NO_3)_2(aq.)$ and 100 mL, 0.4 M NaCl(aq.):
   a. $Q > K_{sp}$
   b. $Q < K_{sp}$
   c. $Q = K_{sp}$
   d. Relation does not exist

   Answer: a

   Solution: Given K_{sp} of $PbCl_2 = 1.6 \times 10^{-5}$

   $Pb(NO_3)_2$: mmoles= 300 mL $\times$ 0.134 M = 40.2

   NaCl: mmoles = 100 mL $\times$ 0.4 M = 40

   This implies, $[Pb]^{2+} = \frac{40.2}{400} \approx 0.1$ M

   $[Cl]^- = \frac{40}{400} = 0.1$ M

   $Q_{sp} = [Pb^{2+}][2Cl^-]^2 = 4 \times 10^{-3} > K_{sp}$

8. Which of the following cannot act as both oxidising and reducing agent?
   a. H_2SO_3
   b. HNO_2
   c. H_3PO_4
   d. H_2O_2

   Answer: c

   Solution:

   When the oxidation state is maximum it acts like a strong oxidising agent

   When the oxidation state is minimum it acts like a strong reducing agent

   When the oxidation state is between its maximum and minimum, it acts like both an oxidizing and as a reducing agent

   In H_3PO_4, P has a +5 oxidation state and hence can act like a strong oxidising agent. In the rest, the oxidation state is between their maximum and minimum.

9. The first Ionisation energy of Be is higher than that of Boron. Select the correct statements regarding this:
   (i) It is easier to extract electron from 2p orbital than 2s orbital
   (ii) Penetration power of 2s orbital is greater than 2p orbital
   (iii) Shielding of 2p electron by 2s electron
   (iv) Radius of Boron atom is larger than that of Be

   a. (i), (ii), (iii), (iv)
   b. (i), (iii), (iv)
   c. (ii), (iii), (iv)
   d. (i), (ii), (iii)

   Answer: d

   Solution:

   Be (4): $1s^2 2s^2$

   B (5): $1s^2 2s^2 2p^1$

   The electron in $2p^1$ can easily be extracted.

   The penetrating power is of the order: s > p > d > f

   The shielding power order: s > p > d > f

   As we move along the period, the size decreases, as Z_{eff} increases. Hence the radius of B is smaller than the radius of Be.

10. For $[PdFClBrI]^{2-}$, the number of geometrical Isomers = n. Determine the spin only magnetic moment and CFSE for $[Fe(CN)_6]^{n-6}$ (Ignore pairing energy).
    a. $1.73\ B.M., -2\Delta_0$
    b. $2.84\ B.M., -1.6\Delta_0$
    c. $0, -1.6\Delta_0$
    d. $5.92\ B.M., -2.4\Delta_0$

Answer: a

Solution:
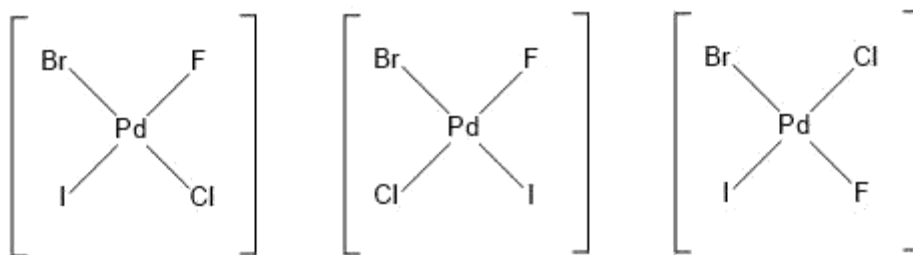
Number of geometrical isomers (n) = 3

$[Fe(CN)_6]^{n-6} = [Fe(CN)_6]^{3-6} = [Fe(CN)_6]^{-3}$

This implies, that Iron is in its +3 oxidation state.

$Fe^{3+}(26): [Ar]3d^5$

CN^- is a strong ligand in $[Fe(CN)_6]^{-3}$ and causes pairing. Hence, according to CFT, the configuration will be $t_{2g}^5\ e_g^0$.

Hence, there is only 1 unpaired electron, i.e, n=1 in $\sqrt{n(n+2)} = \sqrt{3}$ = 1.73 B.M

CFSE = $\left(-0.4 \times n_{t2g} + 0.6 \times n_{eg}\right)\Delta_0$

$= (-0.4 \times 5 + 0.6 \times 0)\Delta_0$

$= -2\Delta_0$

11. A can reduce BO_2 under which conditions?
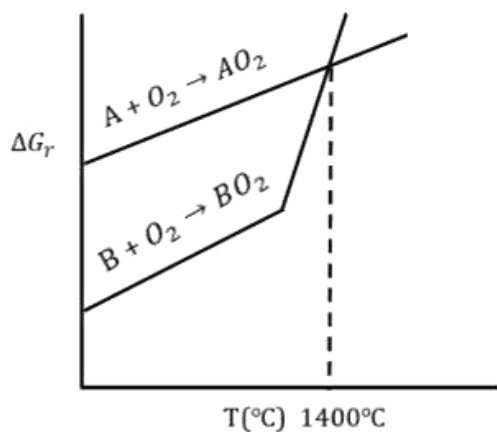
a. $> 1400 \,°C$ b. $< 1400 \,°C$

c. $> 1200 \,°C$ d. $< 1200 \,°C$

Answer: a

Solution: In Ellingham's diagram, the line of the element that lies below can reduce the oxide of the element which lies above it. Therefore, for A to reduce BO_2, the temperature when the line for element A is below that of BO_2, according to the graph when $T > 1400 \,°C$.

For $T > 1400 \,°C$, $\Delta G_r < 0$ for $A + BO_2 \rightarrow B + AO_2$

12. $A \to B$; 700 K

$A \xrightarrow{C} B$; 500 K

Rate of the reaction in absence of catalyst at 700 K is same as in presence of catalyst at 500 K. If catalyst decreases the activation energy barrier by 30 kJ/mol, determine the activation energy in presence of catalyst. (Assume 'A' factor to be same in both cases)

a. 75 kJ
b. 135 kJ
c. 105 kJ
d. 125 kJ

Answer: c

Solution:

$$K = Ae^{\left(-\frac{E_a}{RT}\right)}$$

$$K_{catalyst} = K_{without\ catalyst}$$

Progress of Reaction
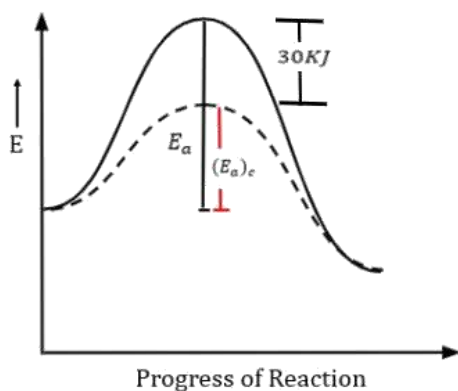
$$Ae^{\left(-\frac{(E_a)c}{RT_{500k}}\right)} = Ae^{\left(-\frac{(E_a)}{RT_{700k}}\right)}$$

$$e^{\left(-\frac{(E_a)c}{RT_{500k}}\right)} = e^{\left(-\frac{(E_a)}{RT_{700k}}\right)}$$

$$-\frac{(E_a)\ c}{RT_{500k}} = -\frac{(E_a)}{RT_{700k}}$$

$$(E_a)c = E_a - 30$$

$$-\frac{(E_a-30)}{T_{500k}} = -\frac{(E_a)}{T_{700k}}$$

On Solving, $E_a = 105\ kJmol^{-1}$

13. A substance 'X' having low melting point, does not conduct electricity in both solid and liquid state. 'X' can be :
    a. Hg
    b. SiC
    c. ZnS
    d. CCl_4

    Answer: d

    Solution: CCl_4 is non polar and does not conduct in either solid or liquid state.
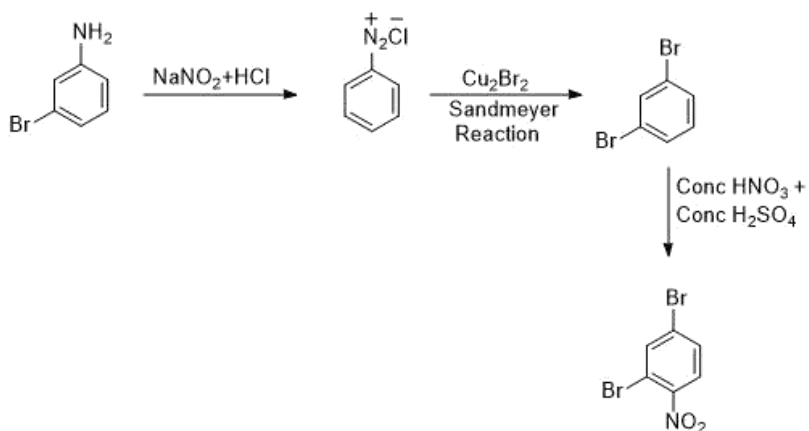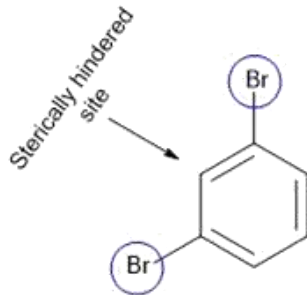
14.

(1) $NaNO_2$ + HCl

(2) Cu_2Br_2
(3) HNO_3, Conc.H_2SO_4
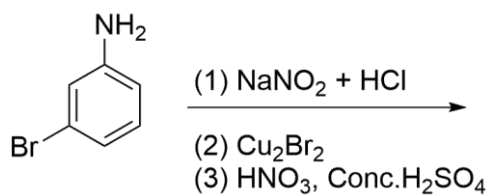
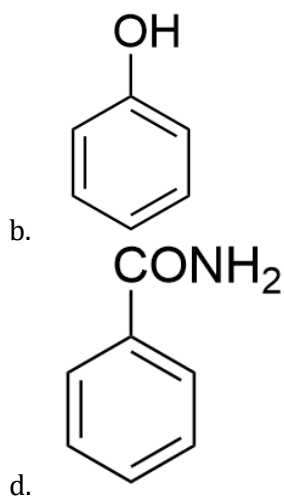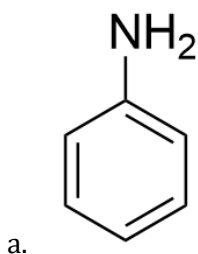The major product for above sequence of reaction is:

a.

b.

c.

d.
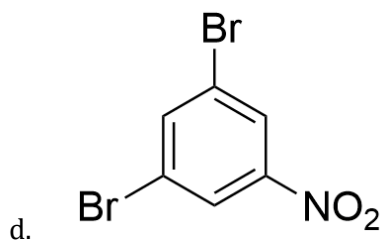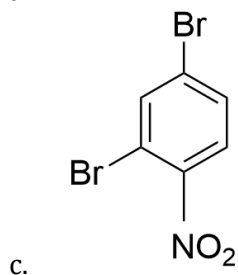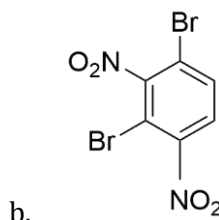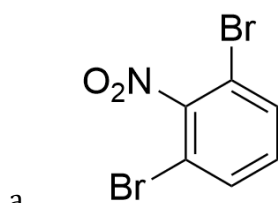
Answer: c

Solution:

Hence, major product formed is that of option b.

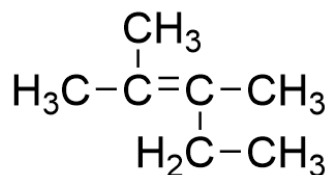15. Which of the following can give the highest yield in Friedel-Craft's reaction?

a.

b.

c.

d.
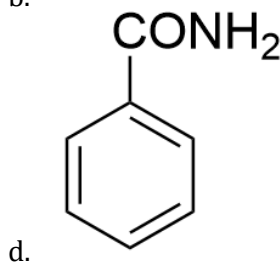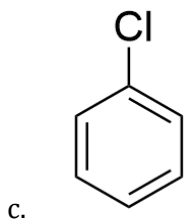
Answer: b

Solution: Out of the four options given, only aniline and phenol show strong +R effects, but as we know, aniline is a Lewis base and can react with a Lewis acid that is added during the reaction. Hence, Phenol gives the highest yield in Friedel-Craft's reaction.
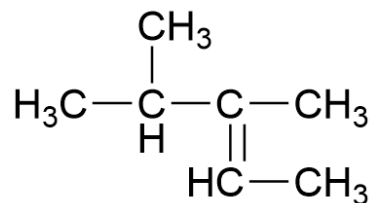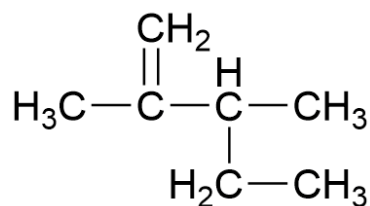
16.

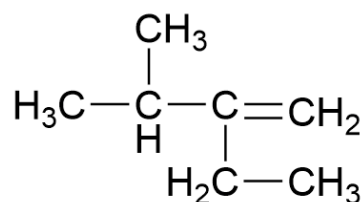$$H_3C-\underset{\underset{H}{|}}{\overset{\overset{CH_3}{|}}{C}}-\overset{\overset{O}{||}}{C}-CH_3 \quad \xrightarrow[\text{(2) H}_3\text{O} \oplus]{\text{(1) EtMgBr/ Ether}} \quad \xrightarrow[\Delta]{\text{H}_2\text{SO}_4}$$
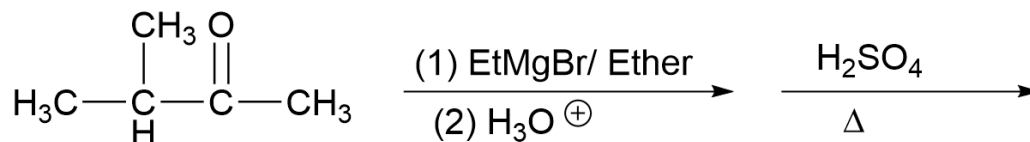
What will be the major product?

a.

$$H_3C-\underset{\underset{H_2C-CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}=C-CH_3$$

c.

$$H_3C-\underset{\underset{HC-CH_3}{|}}{\overset{\overset{CH_3}{|}}{\underset{H}{C}}}-\overset{\overset{|}{||}}{C}-CH_3$$

b.

$$H_3C-\underset{\underset{H_2C-CH_3}{|}}{\overset{\overset{CH_2}{||}}{C}}-\overset{\overset{H}{|}}{C}-CH_3$$

d.

$$H_3C-\underset{\underset{H_2C-CH_3}{|}}{\overset{\overset{CH_3}{|}}{\underset{H}{C}}}-C=CH_2$$
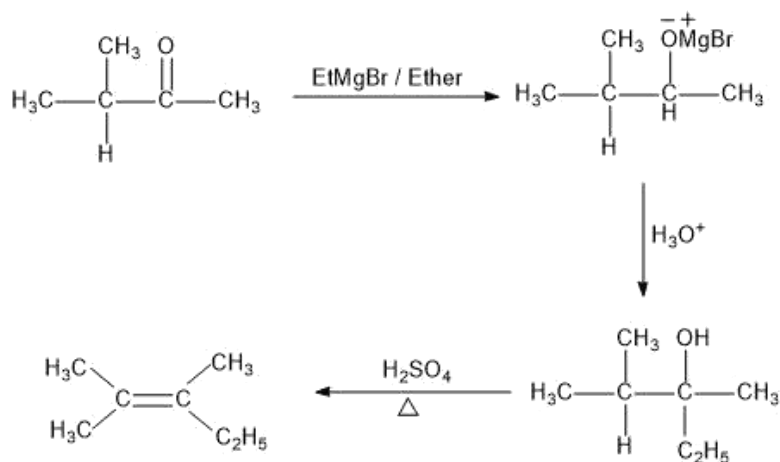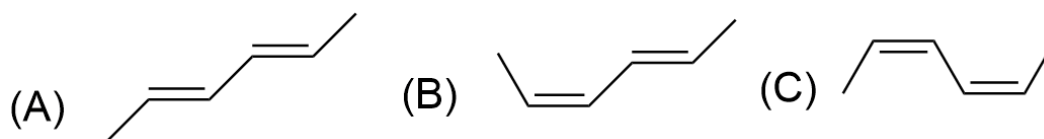
Answer: a

Solution:

17. Which of the following is the correct order for heat of combustion?

(A)   (B)   (C)
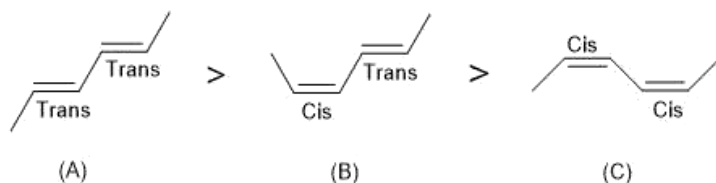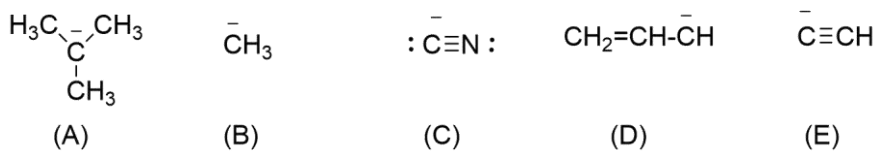
a. C > B > A
c. A > B > C

b. B > A > C
d. C > A > B

Answer: c

Solution: Heat of combustion $\alpha \frac{1}{\text{stability}}$

The trans-isomer is more stable than the cis-isomer. More the number of trans forms in a structure, higher the stability.

(A)   (B)   (C)

18. Write the correct order of basicity:

(A)   (B)   (C)   (D)   (E)
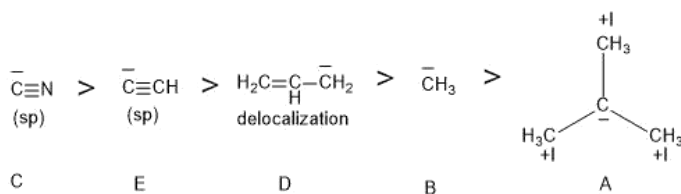
a. A > B > D > E > C
c. A > B > E > D > C

b. B > A > D > C > E
c. C > E > D > B > A

Answer: a

Solution: As we know weaker the conjugate base, stronger the acid.

The order of stability of conjugate base:

Hence, the order of basicity or acidic strength is:

A > B > D> E> C

19. A, B, C, and D are four artificial sweetners.
    (i)   A & D give positive test with ninhydrin.
    (ii)   C form precipitate with AgNO3 in the lassaigne extract of the sugar.
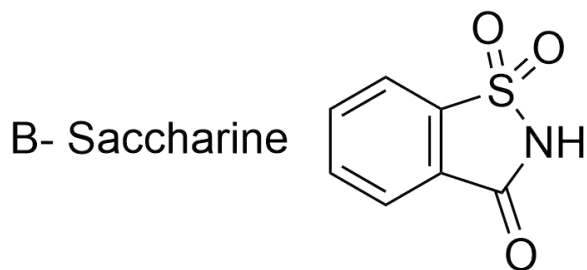   (iii) B & D give positive test with sodium nitroprusside.
Correct option is :
  a. A – Saccharine, B – Aspartame, C – Sucralose, D – Alitame
  b. A – Aspartame, B – Saccharine, C – Sucralose, D – Alitame
  c. A – Saccharine, B – Aspartame, C – Alitame , D – Sucralose
  d. A – Aspartame, B – Sucralose, C – Saccharine, D – Alitame
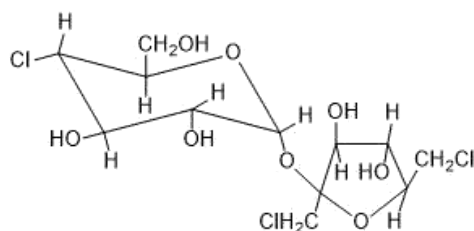
Answer: b

Solution:
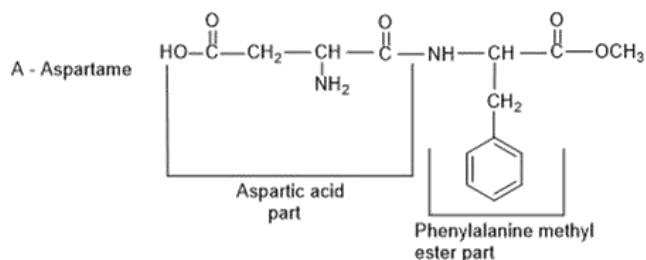
It has a free amine group and hence reacts with ninhydrin to give a purple colour known as Ruhemann's purple.
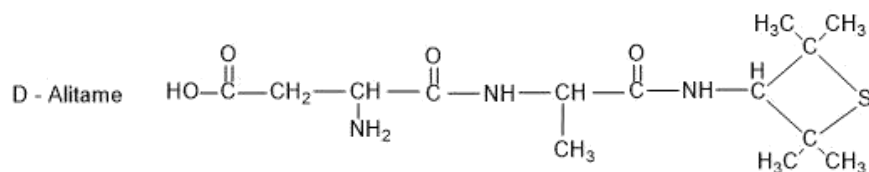

It has Sulphur, therefore, it will give a positive test with sodium nitroprusside.

C - Sucralose

It has chlorine and hence it forms a precipitate with $AgNO_3$ in the Lassaigne's extract of the sugar.
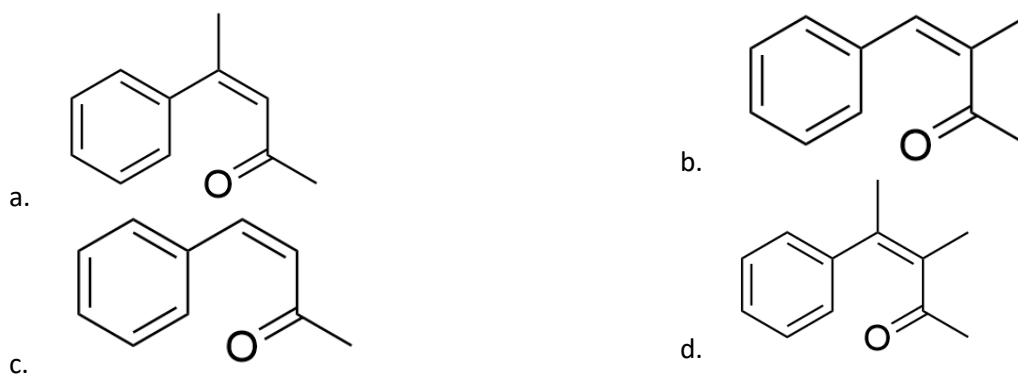

D - Alitame

It has a free amine group and hence reacts with ninhydrin to give purple colour known as Ruhemann's purple. Also, it has Sulphur, therefore, it will give positive test with sodium nitroprusside.
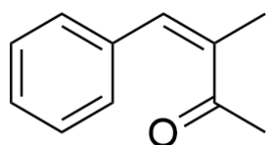
20.

Predict the compound (P) on the basis of above sequence of the reactions, where compound (P) gives positive Iodoform test:
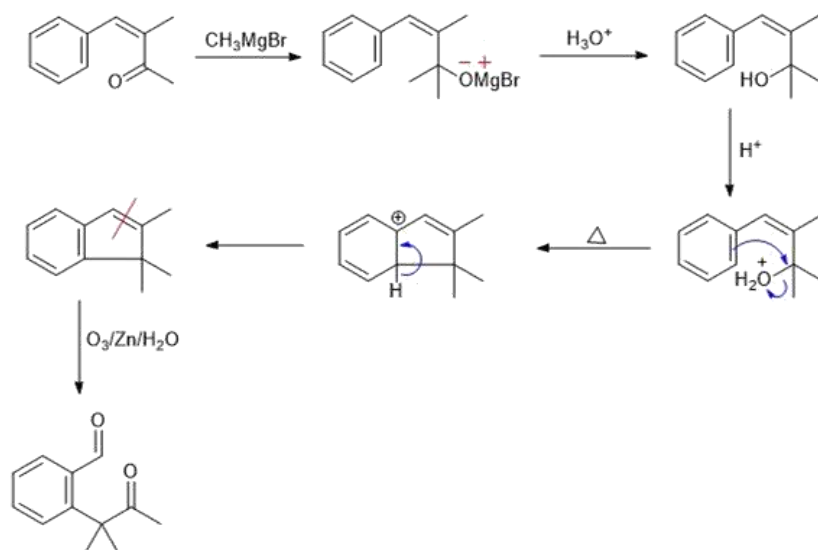
a.

b.

c.

d.

Answer: b

Solution:

 is a methyl ketone, which gives positive Iodoform test.

21. Given a solution of HNO_3 of density 1.4 g/mL and 63% $\frac{w}{w}$. Determine molarity of HNO_3 solution.

Answer: 14.00

Solution: $\%\frac{w}{w} = 63\%$

$\rho = 1.4$ g/mL

$$M = \frac{\left(\%\frac{w}{w} \times \rho \times 10\right)}{MM}$$

$$M = \frac{(63 \times 1.4 \times 10)}{63}$$

M= 14 mol/L

22. Determine the degree of hardness in terms of ppm of $CaCO_3$ of 10^{-3} molar $MgSO_4$ (aq).

Answer: 100.00

Solution:

Hardness of water is measured in ppm in terms $CaCO_3$.

$n_{CaCO_3} = n_{MgSO_4}$

ppm is the parts (in grams) present per million i.e, 10^6

1000 mL has 10^{-3} moles of $MgSO_4$.

Grams of $CaCO_3$ in 1000 mL = $10^{-3} \times 100$ grams

Grams of $CaCO_3$ in 1 mL = $\frac{10^{-3} \times 100}{1000 \text{ mL}}$ grams

Hardness = $\frac{10^{-3} \times 100}{1000 \text{ mL}} \times 10^6 = 100$

23. Determine the amount of NaCl to be dissolved in 600 g of H_2O to decrease the freezing point by 0.2°C. Given : k_f of $H_2O = 2 \text{ Km}^{-1}$

Answer: 1.76

Solution: NaCl is strong electrolyte and gives 2 ions in the solution. This implies, i=2.

Molatility= $\frac{w \times 1000}{58.5 \times 600}$

$\Delta T_f = 0.2°C$

$\Delta T_f = i \times k_f \times m$

On solving we get,

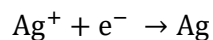w= 1.76grams

24. On passing a particular amount of electricity in $AgNO_3$ solution, 108 g of Ag is deposited. What will be the volume of $O_2(g)$ in litres liberated at 1 bar, 273 K by the same quantity of electricity?
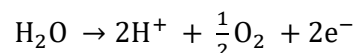
Answer: 5.68

Solution: On applying Faraday's 1st law,

Moles of Ag deposited= 108/108= 1 mol.

$Ag^+ + e^- \rightarrow Ag$

1Faraday is required to deposit 1 mole of Ag.

$H_2O \rightarrow 2H^+ + \frac{1}{2}O_2 + 2e^-$

$\frac{1}{2}$ moles of O_2 are deposited by 2 F of charge.

This implies, 1 F will deposit $\frac{1}{4}$ moles of O_2

Using PV=nRT
P= 1 bar
T= 273 K
R= 0.0823 Lbar $mol^{-1}K^{-1}$
On solving we get,
V = 5.68 L

25. Find percentage nitrogen by mass in Histamine?

Answer: 37.84

Solution:

Molecular mass of Histamine= 111

In Histamine, 3 Nitrogens are present (42g)

The percentage of Nitrogen by mass in Histamine = $\frac{42}{111} \times 100$ = 37.84%